Recommendations for the Idaho National Laboratory to Develop as a World-Class National Laboratory

Report of the NEAC Facilities Subcommittee

October 1, 2016

Executive Summary

The Idaho National Laboratory exhibits many attributes of a world-class national laboratory. There is a strong leadership team in place, a mission important to the nation, strong growth as a multi-program laboratory and a growing ability to attract world-class talent. It is increasingly seen as a world-class laboratory by other national laboratories, the university community, the international community and industry. There is the potential for siting a new reactor at the INL, important for cementing its role as a leader in nuclear power technology.

However, there are challenges. INL support for industry is hampered by high costs, difficult access and limited resources. INL's lead role in nuclear-power development is hampered by lack of a public/political consensus on the role of nuclear energy in meeting the nation's needs. Each of these barriers can be overcome and recommendations for doing so are provided herein. The most important of those recommendations are as follows:

1. *Motivate and facilitate increased access by private entities to Lab expertise and world class user facilities. The role of the Nuclear Science User Facilities (NSUF) in providing information, access and expert support for private investment at facilities and expertise across the complex should be broadened and internationalized as part of this initiative.*
2. *Expand The Gateway for Accelerated Innovation in Nuclear (GAIN) program, which is an excellent start in reducing cost and procedural barriers to private investment in advanced nuclear technologies.*
3. *Leverage the expertise at the INL as a multi-program laboratory and its partnership with other laboratories, especially NREL, to provide renewable-energy expertise that establishes the context within which nuclear power choices exist.*

4. *DOE/NE, ID and INL should jointly enumerate the elements of an oversight model that addresses DOE's key objectives, namely: (1) recognizing values, (2) continuing to build trust, (3) maintaining alignment and quality, (4) maximizing impact, (5) managing effectiveness and efficiency, and (6) ensuring lasting change.*
5. *Evolve the lab culture to one that takes the long view, embraces collaboration, innovation and competition on ideas. Emphasize high-impact publications and other metrics associated with excellence in technology commercialization.*
6. *Continue efforts to cultivate institutional support from ORNL, ANL and other national laboratories for major nuclear energy initiatives, such as the construction of a new reactor to enable the testing and demonstration of advanced nuclear technologies.*
7. *Attract and retain world-class employees to advance the Lab's capabilities and further enhance its technical contributions and recognition.*
8. *Establish a formal framework for collaboration between national laboratories that establishes a reasonably stable, accepted role for each.*
9. *Develop an international strategy to: (a) optimize collaboration in S&T programs, skills development and facilities access/development, and (b) build effective frameworks for INL engagement with international agencies (IAEA, NEA/OECD, GIF).*
10. *DOE-NE and EM should begin discussion with the state of Idaho to update the settlement agreement to reflect current realities and opportunities for Idaho.*
11. *INL management should reach out to watchdog groups to establish a means of keeping these groups informed on a regular basis of lab activities, including research activities, and seek where appropriate their input regarding lab objectives and operations.*

Charge to the Subcommittee

In November, 2015, John Kotek, the assistant secretary for Nuclear Energy, asked that the Nuclear Energy Advisory Committee (NEAC) undertake a review of those actions that could be taken to enhance the role of the Idaho National Laboratory as a world-class national laboratory. In part, the charge letter stated the following:

"...request that NEAC now undertake a forward looking review of where you believe the Idaho National Laboratory should be ten years from now to maintain overall world-class status in nuclear energy research, development, and demonstration, and considering its role as a maturing multi-program national laboratory."

"The review should result in a summary report providing any recommended actions for NE and BEA to achieve the ten-year end-state for the INL, in terms of leadership, governance, oversight, program engagement, user facility approaches, ownership, stewardship and partnership."

Approach

Consistent with this charge, the Facilities Subcommittee of NEAC has taken the following approach:

1. Identify **Opportunities** for the INL consistent with the environment that exists today and is anticipated to exist in 10 years.

2. Identify **Barriers** to reaching those opportunities.

3. Provide **Recommendations** for actions to overcome the barriers and take advantage of the opportunities to enhance the role of the INL as a world-class national laboratory.

*What is a world-class nuclear science and technology laboratory? **

** Drawn from the Report of the Nuclear Energy Research Advisory Subcommittee on Nuclear Laboratory Requirements, September 30, 2004.*

Very briefly, a world-class nuclear science and technology research, development and demonstration (RD&D) laboratory is generally considered as one that is recognized by peers, customers and competitors as one of the best in research in a broad range of nuclear technologies and related fields, leads in the introduction of new technologies into the marketplace, attracts close interactions with other leading organizations on a national and international scale, has the respect and admiration of and is looked to as a key partner by worldwide industry, attracts top talent into career paths and hosts top students, Post Docs, and faculty in research opportunities , and is known and admired in public circles.

There are a number of requirements that must be met in order to have a "world-class" laboratory and that are represented in all world-class laboratories. These include:

- A well-defined mission of sufficient scientific or applied interest that a funding agency (or corporate entity) has a continuing interest in broad and sustained funding.
- A director and leadership team that combines broad experience in the field concerned, outstanding scientific and applied judgment, and success in managing research organizations.
- Excellent staff that is recognized internationally.
- The authority and freedom for the leadership team sufficient to manage the laboratory while being held accountable for the laboratory's performance.
- Leadership and staff in the funding agency that is sufficiently knowledgeable to measure the laboratory's performance, demonstrates confidence in the ability of the Laboratory Leadership to lead, and that have sufficient authority to make timely decisions for the sponsor.
- Substantive interaction with peer technical and relevant policy communities.

Background

The Idaho National Laboratory (INL) is DOE-NE's lead laboratory for nuclear-power-technology research, development and demonstration. As a lead laboratory, it provides core capabilities and coordination with other national laboratories that have expertise in the technology. It hosts major test facilities and manages the Nuclear Science User Facilities (NSUF), a distributed user facility providing access to test facilities and expertise across the national laboratory, university, industrial and international nuclear communities. In short, it has major responsibilities for enhancing its own capabilities while working closely with partners across the nuclear-research community.

The INL is also a multi-program laboratory, with major programs in national security, other dimensions of energy, and environmental science. As such, it maintains important relationships with programs inside and outside of DOE, especially where nuclear technology is involved. These programs have been successful in attracting significant talent to the INL and in expanding understanding of broader aspects of nuclear technology.

A particular advantage for INL's experimental programs is its location, an 890 square-mile site in Southeast Idaho that served as the nation's reactor-testing station. Some 52 test and prototype reactors were operated there. The site remains an ideal location for testing large-scale energy systems, especially nuclear.

An important component of the INL is the Center for Advanced Energy Studies (CAES), providing a semi-independent organization led by a consortium of universities with the ability to address both technical and policy considerations of energy-technology choices.

Taken together, these capabilities provide significant opportunities for the INL at a time of significant need in its mission areas. Never has there been greater interest in energy technology choices, the role of nuclear power and the need to address climate change effectively. The opportunities for the INL are great.

Goals as identified for the INL by Mark Peters, Director, are as follows:

1. Continue to mature as a multi-program national laboratory.
2. Be an organizer and leader for the community around a nuclear energy strategy for the Nation.
3. Establish the national framework for addressing challenges in control-system cyber physical-security.
4. Develop and demonstrate clean energy systems at scale.
5. Collaborate with industry at the pace of business.
6. Building on the foundation of people, facilities, and capabilities, raise the scientific and technical impact of the lab through addressing big national and global challenges, hiring and retaining great people, and modernizing facilities and infrastructure.
7. Increase the scientific and technical impact of the Laboratory through high quality publications and innovations, a focus on internal and external collaborations, and increased Laboratory-directed investments
8. Raise the Laboratory profile in the State and region.
9. Continuously improve the safe, secure, and efficient operations of the Laboratory.

The Subcommittee has reviewed these goals and finds them both important and achievable.

The INL has grown considerably as a multi-program laboratory, a trend important to continue. Growth as a multi-program national laboratory has increased budgets, attracted significant talent and provided important ties to other elements of DOE and DOD.

The INL has the opportunity to be a leader around a nuclear energy strategy for the Nation, an opportunity yet to be realized. However, there is the opportunity (and the need) to do so.

Cyber physical-security is a somewhat unique capability at the INL and is especially important for the operation and protection of nuclear power plants. Both because of the talent at the Laboratory and opportunities for testing, this is an important initiative for the future of the INL.

The INL site provides an important resource for building and testing energy systems at scale, including nuclear. It has the physical resources necessary to support such initiatives across a range of clean-energy technologies and is an important aspect of its multi-program growth.

Collaboration with industry is especially important given the fact that technology leadership in nuclear power is increasingly coming from industry. There is significant opportunity but also significant barriers that must be overcome to meet expectations of industry.

Significant achievements since the INL was formed include the construction of new facilities, hiring of talented people and development of an outstanding management team. It is a trend that if continued, will further cement the INL as a world-class national laboratory.

Raising the scientific and technical impact of the laboratory requires an emphasis on people and innovation. These trends are important to both retain and attract talent necessary for the INL to grow as an internationally-recognized national laboratory.

The INL profile in the state of Idaho and the region is especially important for the Northwest. The INL provides intellectual and technology capital important for addressing issues of energy choices unique to the area.

Safe, secure and efficient operations are essential to success of the INL, given the large number of nuclear facilities at the site. The challenge is to succeed in all three, namely safe, secure and efficient.

Discussed below are those opportunities, associated barriers and recommendations seen as especially important for the success of the INL.

Views of the INL from Others

The reputation of the INL is an important indicator of its success in becoming a world-class national laboratory. Accordingly, we sought the opinions of the

international community, the national laboratory community, industry and the public. Summarized below are the results of that inquiry.

Views of the INL from the international community

The opportunity exists to enhance the delivery of INL's mission by growing strategic engagement and exerting global influence through international partnerships. This Chapter summarizes the international community's perspective on INL as a world-leading national laboratory and highlights both the opportunities and the potential barriers to INL's international profile, engagement and influence.

In assessing the international community's perspective on INL, the Panel engaged approximately twenty senior nuclear industry experts based in seven counties within Western, Central and Eastern Europe, and Asia. The Panel circulated a short questionnaire to the experts, and their responses form the basis of the discussion in this Chapter.

The international community recognizes INL as an internationally leading US DoE national laboratory in key areas specific to its mission. However, the community suggests that INL cannot fully achieve its mission and objectives without developing a more effective engagement with the global nuclear community. There are significant drawbacks to operating without effective international engagement, e.g. reduced scale of nuclear R&D programs, poor access to international experts, lack of access to specific facilities, lack of access to financial sharing and a reduced reputation and scientific credibility. The benefits to strategic international engagement are considerable and include engagement in significant international programs, facilities and capabilities e.g. on Enhanced Accident Tolerant Fuel (EATF), access to international facilities and hosting international researchers at INL facilities, engagement with internationally renowned experts, and exerting international influence and leadership.

The following five areas form the focus for international perspective on INL's capability as an internationally-leading national laboratory:

Case Study: FUTURIX-FTA

The FUTURIX-FTA (Fuels for the transmutation of Trans-URanium elements in phénIX–Fortes Teneurs en Actinides) project is an international collaboration between CEA, DOE, JAEA & JRC-ITU which is investigating the irradiation behavior of MA-bearing oxide, nitride & metallic fuels. A number of fuel pins underwent irradiation in the Phénix sodium fast breeder reactor and the INL's ATR. [1]

The work was completed under a bilateral agreement and fuel transportation between partner organisations several months of preparatory engineering and coordination work involving the member organisations, regulators and other stakeholders.

PIE of the fuel elements will generate useful data on minor actinide transmutations and will also act to benchmark INL's ATR reactor as results will confirm whether the ATR can adequately recreate fast reactor fuel behavior. This would enable INL researchers to continue to use the ATR in studies of new fuels under its Transmutation Fuels Program [2].

This is an example of work that INL (and the US-DOE) would not have been able to conduct without international co-operation since no fast breeder reactor was or currently is operating in the USA.

1. Programs: International engagement provides access to international nuclear science and technology (S&T) programs, many of which complement INL's existing capabilities. The international community recognize INL's engagement in some topics and highlight that innovative results have been achieved through international collaboration. The community recognizes the need to focus engagement on key topics of relevance to INL's mission.

2. Skills: International engagement provides access to the world's most eminent nuclear experts. The international community recognizes that this not only strengthens S&T programs, but also supports the development of the next generation of skills. International engagement also enables INL to benchmark their own skills. Opportunities for skills development were highlighted including joint working on international projects and secondment opportunities.

3. Facilities: The international community recognizes that INL operates world-leading facilities and value to access INL provides to the community, e.g.

ATR, ATR-C, TREAT, Hot Cell and Instrumentation Laboratories. However, the community also recognizes that international engagement provides INL with access to other facilities not necessarily available in the USA, e.g. access to Belgium Reactor (BR) 2 at SCK•CEN, access to Halden at IFE (Norway) and Studsvik hot-lab facilities (Sweden) following ATF irradiation testing in the HBWR. Engagement enables facilities sharing, further enhancement of the research infrastructure available and financial gearing of programs to enhance value for money and reduce costs.

4. Leverage: The community recognizes the considerable economic-benefit that can be gained by leveraging international funding, facilities and resources. International engagement therefore provides leverage on US investment in nuclear S&T. The economic benefit arises from the ability to deliver larger programs at reduced cost to the USA, the effective cost reduction associated with facilities and staff, and the financial saving from the avoidance of duplicating research together with creation of better fit for purpose programs using all of the scarce international nuclear resources (skills and facilities) available.

Case Study: Halden Reactor Project (HRP)

The Halden Reactor allows fuel rods to be tested in numerous conditions (power, temperature, pressure, coolant chemistry) and all rods are equipped with in-pile instrumentation that provides direct insight into fuel performance phenomena during irradiation.

Contribution to the HRP allows members to perform irradiation studies, conduct post irradiation evaluation (PIE) assessments and access data from both current and historical Halden irradiation experiments. An example of the importance of the HRP to INL is that the BISON fuel performance code has 16 (out of 48) validation cases based on Halden fuel rod irradiations.

The USDOE contributes 3,000,000NOK (~$350k) to the HRP over a three-year period whilst the total monetary contribution from all partners of the HRP over this period totals 413,000,000NOK (~$48m). This shows that membership of the HRP, as well as providing access to technical expertise and a world class irradiation facility, represents a considerable economic benefit to INL.

5. Leadership: The international community recognize the role that INL could play, given its capability, in providing international leadership and influence. INL provides international leadership by virtue of representing U.S. government positions, interests, and priorities. This participation enables them to influence the scope and direction of international collaborative programs. INL already provides and receives strategic advice from the international community in a number of ways, e.g. external advisory boards, working groups, specialist meetings / seminars, engagement with OECD/NEA and IAEA etc.

Whilst recognizing the benefits of international engagement and being aware of some specific examples of international collaboration, the international community is largely unaware of INL's international strategy. A review of INL's Vision and Strategy paper indicates that they "collaborate with regional, national, and international leaders in academia, industry, and government". However, there is no detail regarding the strategy to do so effectively. One barrier to maximizing the benefit that INL can draw from international engagement and the influence it can exert on the international community is the reliance on an ad hoc approach to international engagement and a lack of strategy.

The international community recognizes INL's technical expertise in key fields of S&T, and value the engagement for these experts in international programs, e.g. Dr. Terry Todd in the field of actinide separations. One barrier to international engagement is the management encouragement and financial support provided for staff engagement with the international community, e.g. through in-kind contributions to European programs, attendance at expert meetings and conferences, and secondments.

The issue of Intellectual Property (IP) management is considered a potential barrier to international engagement in research, leading some to avoid collaboration. However, it has been found from those who have engaged with INL that there is a reasonable level of understanding regarding the treatment of background and foreground IP.

Recommendations

As stated above, the international community recognizes INL's leading capability and the opportunity afforded to deliver its mission through effective international engagement. To maximize the benefit to INL, it is recommended that an *international strategy be developed to: (a) optimize collaboration in S&T programs, skills development and facilities access/development, and (b) build effective frameworks for INL engagement with international agencies (IAEA, NEA/OECD, GIF). Doing so will help ensure that the INL contributes to activities of significant interest for the international community, establishing an important U.S. presence.*

With respect to the five areas addressed, the following recommendations are made:

1. Programs: The community noted that in certain fields the amount of data that is gathered in international research projects is very substantial. However, the data gathered is poorly exploited and left unpublished mainly due to time and funding constraints. *INL should therefore consider conducting yearly reviews of all international collaborative projects and record how many papers are published from these projects when compared with non-collaborative projects.* This would increase the visibility/impact of the research INL is conducting within international programs.

2. Skills: The community noted the benefit of technical skills development through the engagement and secondment of scientific staff through international programs. *INL should therefore consider including skills development as a feature of its international engagement strategy, including the receiving as well as the sending of scientists via an international secondment program.*

3. Facilities: Given the considerable benefit that sharing of large scale facilities internationally has on enhancing progress on international programs, e.g. ATF and Gen IV systems, *INL should consider how it might more effectively*

engage with key existing and emerging international facilities e.g. NNL Central Laboratory, Jules Horowitz Reactor, Haldenand ASTRID. Enhancing international access to its own facilities would be of interest to the international community, e.g. through expanding the remit of the Nuclear Science User Facilities (NSUF) to include international users through an appropriate funding model.

4. Leverage: Whilst international collaboration provides considerable leverage, particularly where large facilities are involved, only a small portion of the international community were able to provide even rough data for the economic and other benefits of international collaboration. *It would therefore be useful for INL to quantify relevant indicators regarding the benefit of international engagement.* These might include both 'hard' and 'soft' indicators including: (a) new knowledge/data gained through joint publications, (b) financial benefit through cost-saving and leverage, (c) skills developed through scientist exchange programs, (d) IP generated through patents and their valorization (licenses, royalties).

5. Leadership: The international community recognized the important role INL senior experts could play in exerting international leadership and influence. *INL should consider how it might support greater engagement of its senior staff in key international agencies and expert panels as part of a wider international engagement strategy.*

Views of the INL from the National Laboratory Community

As DOE's designated lead laboratory for Nuclear Energy, the INL fulfills a key role as an organizer for the nuclear energy research community and a strong voice for a proactive nuclear energy strategy for the nation. Building on this role, the NSUF model and other inter-laboratory initiatives, INL is well positioned to partner with other national laboratories and universities with significant capability in nuclear science and technology. These Laboratories complement INL in supporting DOE's nuclear energy mission. While they conduct work in multiple mission areas for

DOE and other sponsors, this section is focused on their views of the INL related primarily to nuclear energy.

The INL has progressed significantly since its creation in 2004. Cooperation between the Labs on DOE-NE programs is improving, particularly among INL, ORNL and ANL. As the leadership team at INL has been increasingly drawn from these national laboratories, the opportunities for cooperation have increased, and new mechanisms for cooperation have been established as part of the GAIN initiative.

Nuclear energy program leaders and/or responsible ALDs at several national laboratories (ANL, ORNL, PNNL and SNL) were contacted to invite their participation in this review. Each provided responses to a questionnaire soliciting their views and recommendations for the INL.

A summary of Lab views regarding opportunities for INL is provided in Table 1. These opportunities are organized under the following headings: a) Lab mission, b) facilities and user access, c) personnel, and d) inter-Lab collaborations. Key opportunities that were identified include:

- Enhanced recognition of the benefits of nuclear power generation by the public and policy makers,
- Demonstration of advanced nuclear technologies in collaboration with industry, other national labs and universities,
- Further development of the national nuclear energy R&D infrastructure through the construction of a new test reactor to meet anticipated testing needs.

Table 1: Summary of National Lab views on opportunities for INL

Mission (Nuclear Energy RD&D Leadership): ▪ Increase recognition of benefits of nuclear power generation, and understanding of risks. ▪ Contribute to addressing short term competitiveness challenges facing nuclear energy. ▪ Demonstrate advanced nuclear technologies in collaboration with industry, Labs and universities: - Advance one or more advanced reactor systems toward demonstration in collaboration with industry, - Demonstrate performance and attractiveness of enhanced accident tolerant fuels (EATF), - Select advanced/sustainable fuel cycle(s) for development and demonstration, - Refine the vision, technical objectives, and R&D activities for hybrid nuclear/ renewable systems, - Support the commercial deployment of LW-SMR, - Support the economic and safe operation of LWR and extension of LWR plant lifetime (2nd license renewal).
Facilities and user access: ▪ Build a new reactor, filling a gap in national and international testing capabilities. ▪ Facilitate access to facilities/instruments, samples, simulation tools, and databases of nuclear energy technology. ▪ Enhance efficiency of facility operations in support of R&D consistent with best-in-class nuclear, radiological and industrial safety.
Personnel: ▪ Continue to develop world class work force.
National Lab Collaborations: ▪ Continue to build NE collaborations across the DOE complex; employ capabilities at DOE Labs to enhance cost effectiveness, timeliness and quality of RD&D results. ▪ Enhance collaborations among Labs through effective team building practices, e.g., establishment of goal-oriented multi-organization teams that can potentially transcend inter-Lab competition.

The challenges INL faces as lead lab for nuclear energy RD&D were recognized as being strongly related to the challenging environment for nuclear power generation and development in the U.S. Challenges for inter-Lab collaboration include the lack of a formal framework for collaboration that establishes a reasonably stable, accepted role for each Lab. Such a framework could be effective, particularly if it recognized and rewarded management and staff at

national labs for contributions to productive collaborations that deliver high-impact benefits for the nation in a cost effective manner.

Table 2: Summary of National Lab views on barriers/challenges faced by INL

Status of Nuclear Energy Application and Development in the U.S. ▪ Current/near-term competitiveness challenges for nuclear plants, particularly in deregulated markets (early plant closures): - Low cost of natural gas motivates its expanded use for electricity generation and reduces electricity price, - Energy and market policies at national, regional and state levels favor renewable energy sources (wind, solar) in comparison to nuclear generation. ▪ Effective communication to address societal concerns about nuclear safety, SNF/waste management, and proliferation. ▪ Achievement of high impact RD&D results in view of - Budget constraints, - Nature/extent of Federal government role in supporting the nuclear energy industry.
INL History and Status ▪ History of the INL as an engineering laboratory with an emphasis on nuclear facility operation and engineering scale demonstrations, not innovation in technology development or in-depth scientific investigations underpinning technology advancement. ▪ Competition with other research organizations and industry for talented engineers and scientists.
Collaboration with Other National Labs ▪ Further improvement of trust among Labs. ▪ Establishment of reasonably stable, accepted role for each Lab. ▪ Competition among Labs when funding is insufficient or declining.

Recommendations:

INL should continue building its role and capacity to serve as a catalyst for a more focused nuclear energy RD&D program that serves national objectives in the energy realm and effectively utilizes the nuclear energy capabilities distributed across the national laboratory system. INL should continue its efforts to cultivate institutional support from ORNL, ANL and other national laboratories for major nuclear energy initiatives such as the construction of a new reactor for technology testing and demonstration in the US. Moreover, the national NE R&D program should be focused to a greater extent on the demonstration of high-impact

nuclear energy technologies in collaboration with industry. Such added emphasis on technology demonstration and commercialization would enhance the benefits of supporting research and facilitate communication of its importance to the public and policy makers.

A second key recommendation is that INL and CAES should team with experts at other organizations to advance energy-system-analysis capabilities, with the aim of clarifying the benefits and drawbacks of alternative energy strategies. Such analysis capabilities are needed to substantiate and clarify the role and benefits of nuclear energy generation and would support the development of sound energy strategies at the national and regional levels.

While advancing energy-system analysis capabilities*, INL should champion work that advances its nuclear energy mission and the broader national interest across the national laboratory system,* taking advantage of the distinctive capabilities and resources at each institution.

To demonstrate to the broader community its progress as a premier R&D laboratory*, INL should establish and track measures of its performance. For example, publications and citations in premier journals and successes in commercialization of INL developed technologies.*

Views of the INL from Industry

The approximately 100 operational Light Water Reactors (LWRs) in the US generate approximately 20% of the electricity requirements for the nation. These existing reactors represent close to $800B of national infrastructure. Many of these reactors will undergo plant-lifetime extension programs to extend their operational life for several more decades. The INL Research and development (R&D) capabilities to support the existing reactor fleet is important for future of these plants. As all utilities are currently looking at ways to cut their operational and maintenance (O&M) costs by 30%, research that supports this goal is important.

The nuclear industry is an international community and incidents in one country have a marked impact on operations in all other countries. To improve the safety

of the LWR fleet in the US and internationally, R&D capabilities are required to develop Enhanced Accident Tolerant Fuels that provide additional coping time in an accident scenario. As such the irradiation and post irradiation examination capabilities at INL such as ATR and TREAT are important infrastructure that is required to support EATF development.

However, although the INL is well recognized by other research organizations around the world, there is a lack of knowledge and understanding of INL capabilities in industry, especially international industry.

There is extensive interest in the nuclear-power industry to look at alternative options for a new generation of nuclear reactors that can provide other products other than just electricity. This is a long term undertaking and as such INL should expand the infrastructure needed to support the development of the design and licensing of these new reactor designs.

Within the limit of the existing DOE NE budget the INL, the national laboratory system and universities have developed some of the capabilities to support the nuclear industry in the following areas.

1) EATF Fuel development including ATR, TREAT and associated PIE facilities.
2) UNF storage.
3) Support to the continued operation of LWRs.
4) Support to hybrid nuclear and renewable systems.
5) Support to cyber security,
6) Support the development of small modular reactors.
7) Facilities to support next generation of nuclear reactors.

As the lead laboratory for nuclear power development, DOE-NE and the INL must anticipate and accommodate changes in national and international approaches if they are to succeed. The model for development of advanced nuclear power technology is changing in important ways. Innovators from the private sector, often in collaboration with established industry-entities, are providing new emphasis on advanced nuclear-power technology. The INL has the opportunity to

be a national laboratory that supports these emergent reactor vendors and meets those needs as a trusted partner, not a job shop.

DOE/NE has made significant progress toward the design of programs that support, and hopefully accelerate, the flowering of nuclear innovation taking place in the private sector today. However, there are barriers as follows:

- Technology: The lack of base infrastructure to address specific issues that arise in design or regulatory discussions.
    - A means of cost-effective access to national resources is needed.
- Financing: Limited means to support investor due-diligence for advanced nuclear concepts. (For any partner/investor to provide funds or resources they have to be convinced of the credibility and viability of the project).
    - Relevant analyses and testing of system issues are needed.
- Regulation: Lack of resources and experience to engage with the USNRC.
    - Access to the experience, data and expertise in addressing licensing is needed

One of the barriers to private investment in new nuclear technology is the cost, uncertainty and time required for licensing. Some prototypes and first-of-a-kind systems are going to other countries in part to avoid the cost and time required by US regulatory requirements. The INL's history is that of a national reactor testing site, an important service to industry that could be regained if this trend can be reversed.

The needs of the current industry for licensing support and needs of the advanced reactor community are different. The first group is well established and has significant resources available to address technical issues. The current approach to licensing by the NRC, while expensive, provides a level of certainty important to their economic model. The second group is less well established, with fewer resources, and seek cost-effective flexible approaches, often outside of the US. Two different groups, two different approaches to licensing.

The INL can be an important partner with DOE-NE and the USNRC in facilitating innovation in licensing, hopefully bringing one or more prototype reactors to the site.

To support the on-going storage of used nuclear fuel the INL should increase its capability to demonstrate that the fuel is safely stored and protected. Every effort should be made to work with industry to develop the necessary facilities and develop technology that meets potential changes to regulatory requirements such as safeguards technology.

For industry, the difficulty and cost of accessing capability at the INL and other national laboratories is an important issue. The current contracting mechanism through CRADAS is unacceptable to many companies due to the liability placed on the industrial partner. Every effort should be made to find a new contracting mechanism. The perception by many in private industry is that working with a national laboratory is expensive, unduly complicated, and that the laboratories work to longer time-frames and with uncertain results.

All of the large reactor vendors and many of the small advanced reactor companies are international companies. As such, the current interpretation of the export control rules is another barrier to the use of the national laboratories.

Not all R&D programs succeed. In industry results of the various programs are constantly reviewed and programs that are not yielding results are stopped immediately and the funding transferred to programs that are succeeding. This type of review process needs to be implemented to demonstrate to industry that the R&D is results orientated.

While these barriers are significant, they can be overcome by aggressive action on the part of DOE-NE and the INL.

Recommendations:

Motivate and facilitate access by private entities to Lab expertise and world class user facilities. *The role of the **Nuclear Science User Facilities (NSUF)** in providing information, access and expert support for private investment at facilities and expertise across the complex should be broadened and internationalized as part of this initiative.* The INL is DOE-NE's lead laboratory for nuclear power, meaning that

it is the principal gateway to both facilities and expertise across the national laboratory complex. NSUF serves this role well.

The Gateway for Accelerated Innovation in Nuclear (G*AIN)* is an excellent start in reducing cost and procedural barriers to private investment and should be continued and expanded.*

We suggest a three-pronged approach to expanding the current GAIN program. GAIN has a voucher program that allows companies to contract with national Labs to answer technical questions, provide data or otherwise do research relevant to future industrialization of a design. Granting vouchers also provides an important opportunity for DOE to assess potential for the technology within the context of national needs. *The funding for the existing GAIN program should be greatly increased.*

Secondly, GAIN could be expanded to allow early viability assessments of developer's proposals to be conducted at appropriate institutions with the same level of industry cost-share as for the current GAIN program. Companies would commission studies specific to their system and be able to use the results with potential partners or investors. Essential to this work is protection of Intellectual Property and trade secrets, tools that should be improved and made more uniform in the national laboratory system.

Many of the innovators are new to the field and unaware of what is available to them, especially results of prior research and risks and opportunities associated with their ideas. *Making such information readily available to the investor community is the third recommended prong of an expanded GAIN program.*

To effectively support the investor community, it is important that the INL have the leadership, focus, and support to grow the Lab's innovation capabilities to conceive and develop future nuclear energy systems. (Break down old perceptions of how national labs cooperate with private interests). The key is people*, developing a culture that encourages new approaches to present challenges and dynamic partnering with private interests.*

However, to gain the confidence of the national/international community in nuclear power development*, the INL must demonstrate fiscal responsibility and*

technical capability by completing major projects on time, schedule and budget. Examples are:

- High burn-up demo project for continued storage of UNF.
- Enhanced Accident Tolerant Fuel. Meet the 2022 deadline set by congress for LTA's into a US reactor.
- Complete the LLW facility at INL, the first major DOE capital project in several decades.
- Restart TREAT on schedule.
- Complete NEAMS high impact problems.

View of the INL from the State of Idaho

The Idaho National Laboratory is growing in prominence within the state of Idaho as it has attracted talent for both staff and leadership. Leadership is increasingly engaged with the public and with the university system. The multi-program nature of the INL is facilitating this trend, especially in areas related to cybersecurity and homeland security.

Research agreements with entities spanning the nuclear-energy enterprise allow INL to share proficiencies and research tools that are relevant to private industry and the regional university community. INL research innovation, testing and evaluation apply new energy solutions to safely, securely and sustainably advance nuclear energy, protect infrastructure, expand energy supply and improve efficiency.

Much of the negative publicity and constraint imposed on the INL is the result of problems associated with another entity at the site, namely the clean-up activity. The settlement agreement reached with the state of Idaho dictated a schedule for cleanup and imposed penalties if not met, penalties imposed on research. This has the effect of constraining the Laboratory in some of its most important research to the detriment of both the INL and the State of Idaho. Such is the case today, with much publicity surrounding delays (over which the INL has no control) and penalties directed to the INL. In the public's eye, the INL is responsible.

The Idaho site has a legacy of environmentally unfriendly cleanup and storage of waste with a very loose research mission at the laboratory. However, with the creation of the INL, the research mission has expanded and propelled the Lab into the spotlight as a premier nuclear-research institution. At the same time, significant progress has been made in responsible cleanup, meeting most of the milestones set forth in the Settlement Agreement.

In an effort to change perceptions the intention should be to divorce cleanup activities from research and development, giving the R&D initiatives of the Lab greater prominence in the public's eye.

However, missed milestones for cleanup are negatively influencing the opportunities in R&D, and ultimately those opportunities translate to missed partnerships between industry and university involvement at the lab. By de-linking the cleanup from the R&D mission of the Lab, it will be possible to engage more strongly with the State of Idaho and the Idaho Universities to address challenges facing the State and the Region.

In summary, the settlement agreement is a major challenge and one that DOE needs to fully own so that the lab mission can be understood to be separated from cleanup. This will require constant and trusting communication by all parties, especially cooperation between DOE-NE and EM. The settlement agreement needs to be renegotiated for the benefit of all parties.

Recommendations:

It is recommended that DOE-NE and EM begin discussion with the state of Idaho to update the settlement agreement to reflect current realities and opportunities for Idaho.

At the foundation, a full package adjustment to the agreement is needed, but steps can be taken in the short term to identify the R&D aspect as independent from cleanup in a phased approach.

An important activity would be to rebrand all activities around clean-up as such while emphasizing the R&D nature of the INL. Activities around this would include an educational campaign to create two distinctly branded entities.

In an effort to increase industry knowledge of the Lab, commercialization opportunities that positively impact the state economy should be explored. The work at INL is a critical economic driver and important asset to the state of Idaho. (INL is the fifth-largest employer in Idaho with 3,900 employees and more than 350 interns. In 2015, INL had a total business volume of $917.1 million and spent $130 million with Idaho's small businesses).

It is also recommended that the INL establish a scientific and engineering presence in the Treasure Valley (Boise), locating employees there doing work relevant to needs and interests of Idaho, such as materials science, sensors, cybersecurity, advanced manufacturing and computer simulation and modeling. Consistent with this*, strengthen the presence of the INL across the state of Idaho, further emphasizing INL's importance to the economic health and reputation of Idaho.*

It is also recommended that the capability of the Center for Advanced Energy Studies (CAES) be enhanced to play a major role in focusing regional, national and international policy on energy technology choices. In doing so, involve major universities and internationally recognized experts in addressing energy technology needs and planning.

Views of the INL from the Public

In spite of considerable efforts for outreach, there is limited understanding by many communities in the state of Idaho of the research role of the laboratory. Conversely, it is important for lab management and the lab's technical community to better understand views and concerns of the public. The surrounding communities provide an important resource by which initiatives to address concerns of the broader public can be developed.

Initiatives to reach out to public groups have the benefit of educating all the parties involved regarding important energy and environmental policies and practices, including federal and regional policies and priorities for addressing climate change and waste management practices at the lab. Such interactions

lead to better understanding of the role and potential benefits of nuclear power as an energy choice among the mix of future energy choices.

Locally, the INL has been effective in reaching out to the public and the current senior leadership has both the credibility and desire to become important spokesmen for the INL. However, watchdog groups that have an interest in lab activities, such as the Snake River Alliance, indicate that they have a better understanding of ongoing cleanup activities than research activities at the lab. (They have expressed an interest in learning more about research activities at the lab).

The public perspective of nuclear power is mixed, with strong feelings on both sides of the divide, and there are many views between the extremes of both camps. The vast majority of experts on both sides share the view that addressing climate change is a high, if not the highest, energy priority. Studies and discussions of how best to achieve deep and rapid reductions in carbon emissions, including the respective roles of nuclear power, renewables and improvements in energy efficiency, are in the interest of all parties. Understanding public perspectives is important if progress in going to be made and the US international role is to be maintained.

Cooperation at the technical level with the renewable energy community has been good, especially between the INL and NREL, but cooperation within DOE has been lacking. It is important that the context of energy technology choices for addressing climate change be well understood so that policy makers and the public can make proper decisions.

There is a lack of a national consensus on the role of nuclear power. This is reflected in the decline of US leadership in global nuclear-energy development and lack of a large national project in nuclear power that unifies laboratories, universities and industry. Limited budgets for nuclear power research strain cooperation with other national laboratories competing for the same funding. It is important that the INL provide leadership to address what is a fragmented vision of nuclear power. The goal is to establish the context for nuclear power as a

choice to ensure energy security, national security and to protect the environment.

Recommendations:

INL management should reach out to watchdog groups to establish a means of keeping these groups informed on a regular basis of lab activities, including research activities, and seek where appropriate their input regarding lab objectives and operations.

A good model for keeping the local community informed was the Nuclear Regulatory Commission's (NRC's) advisory committee on the cleanup of Three Mile Island. This advisory committee was chaired by a local politician from the TMI area and members from nuclear community and environmental groups were represented on the committee. The committee held monthly meeting and heard presentations by the utility, its contractors, federal officials and others.

In an effort to seek common ground in the role of nuclear power in addressing climate change, the lab should consider forming *a joint research project with NREL, academic and NGO experts to prepare a report on options for addressing climate change. In this context, leverage the expertise at the INL as a multi-program laboratory and its partnership with other laboratories, especially NREL, to provide the expert analysis that establishes the context within which nuclear power choices exist*. It is important to both DOE-NE and the INL that the public be engaged in understanding of nuclear power as an important component of emission-free power generation.

The Center for Advanced Energy Studies (CAES) associated with the INL is an ideal vehicle for this role, developing a public presence in consideration of energy technology choices. Other institutes and agencies with recognized expertise in multifaceted interests (technical/political/economic/social) bring important insights and should be brought into the discussion through the Center for Advanced Energy Studies. It is important that CAES be seen as an honest broker for these studies, not just nuclear centered. DOE-NE should consider funding special studies led by CAES/INL to address these issues.

DOE Management and Oversight

The Commission to "Review the Effectiveness of the National Energy Laboratories" (CRENEL) provided a comprehensive assessment of the relationship between DOE and the Laboratories that they manage. A key finding was that pockets of transactional oversight at DOE complicate management of the Laboratories. A key indicator of this is when DOE defines not just "what" needs to be performed but increasingly includes stating "how" the work is to be performed. This stifles enthusiasm, increases costs and delays work execution.

It was also found by the Commission, that a culture exists among some within DOE that considers their primary responsibility to find things that are wrong at the Laboratories as opposed to finding ways to advance the programs of the Laboratories they oversee.

The history of DOE's relationship with its laboratories also reveals an escalation of prescriptive orders, stretching resources and limiting the freedom to tailor oversight to the need. For example, the "continuous improvement" clause in many orders is well-intended, but escalates the problems of excessive oversight by equating excellence to contract compliance.

In considering these findings and investigating the situation at the INL, we found many of the same circumstances.

There is recognition of these issues among all parties and many important initiatives have been undertaken to address them. Specifically, a partnership agreement has been created that identifies the objectives of each. There is also strong trust between DOE-HQ, DOE-ID, and INL senior leadership, which needs to continue to be translated down into the DOE and INL organizations. The CRENEL report also recognized that, "The Idaho National Laboratory . . . together with DOE's Office of Nuclear Energy (NE) and the Idaho Operations Office (IOO), has been leveraging the knowledge and experience of SC in tailoring contractor assurance (CAS) to its site. Through these efforts, Idaho should be considered a

top performer with the contractor assurance program, demonstrating a good relationship between the site office and the laboratory. (The creation of CAS was from office of science (SC) defining principles and experience, and Idaho's CAS was customized to fit the new National Laboratory's focused mission). NE, IOO, and Idaho have all been involved in the development of CAS with special emphasis on communication and trust between the laboratory and IOO." (Volume II, page 83). Finally, DOE-NE's response to the CRENEL findings is comprehensive and ongoing. In short, there has been considerable progress, progress that is important to maintain.

The oversight model at INL is colored by the history of the site. The INL site has had many names and many contractors operating different missions. In the last incarnation before the creation of INL in 2004, DOE/EM managed a cleanup mission and a smaller embedded research laboratory, INEEL, through the Idaho Field office. Concurrently, DOE/SC managed the ANL-West portion of Argonne National Laboratory through the Chicago Feld office, via the ANL-West site office. On the formation of INL, DOE/NE took over landlord responsibilities for both and executes them though the Idaho Field office. DOE/NE had no prior experience of managing a laboratory and hence no pre-existing oversight model. As a result, INL and the DOE Field office fell under the inherited EM/ Idaho model.

The Commission to Review the Effectiveness of the National Energy Laboratories (CRENEL) concluded that oversight needed to be reimagined. The DOE response emphasized that, for the labs as a whole;

- "…oversight has grown increasingly transactional rather than strategically mission-driven."
- "…importance of providing an environment in which DOE sets the mission needs and provides oversight, while the managing contractor and laboratory leadership and staff put together the teams and structure programs in response to the mission needs, all in the public interest."
- DOE response is focused on "… (1) recognizing value, (2) rebuilding trust, (3) maintaining alignment and quality, (4) maximizing impact, (5) managing effectiveness and efficiency, and (6) ensuring lasting change."

Increasingly, the INL has gained the trust of DOE-NE and DOE-ID. However, it is important that what has been largely transactional relationship in the past increasingly become one of joint mission development, support and communication. This is important for several reasons, one of which is that to attract the most talented engineers and scientists, there must exist an environment that is supportive of innovation. The stage is well set for this transition as many aspects of the INL's operations have improved. The senior management teams at all three organizations are outstanding and poised to move forward.

Recommendations:

The committee recommends that DOE/NE, ID and INL Jointly enumerate the elements of an oversight model that addresses DOE's key objectives, namely: (1) recognizing values, (2) continuing to build trust, (3) maintaining alignment and quality, (4) maximizing impact, (5) managing effectiveness and efficiency, and (6) ensuring lasting change.

As performance of the INL improves and the contractor assurance program (CAS) demonstrates its effectiveness, DOE oversight can be lessened. As the INL has matured, oversight from DOE-NE and ID can increasingly be redirected to support. For example, there are many issues that could be addressed jointly by teams from both DOE and the INL. Examples include communication with public interest groups, project planning for important initiatives such as TREAT restart, review of DOE orders and procedures that unnecessarily impede progress, etc. The objective is to be proactive in facilitating success of both organizations, anticipating and eliminating barriers to success before problems arise.

Trust between the DOE (both field office and headquarters) and the contractor is essential for effective oversight, especially performance of the contractor-assurance program to identify and disclose issues. An essential aspect of building trust is that DOE-ID regulate to the contract, allowing the contractor to identify and correct problems as they occur. Likewise, the INL builds trust by demonstrating that they have an effective program for doing so. (Increasingly,

DOE-ID is taking a risk-informed approach to regulation, only intervening when the potential for high consequence or public demand requires it. High profile safety lapses in the past have required this but improvements in lab management and oversight have made such events less likely).

The INL should propose alternatives to burdensome and non-value added DOE contract requirements.

Finally, an often-unrecognized capability at DOE-ID is significant experience and capability in oversight and regulation of large nuclear facilities. Over the years, 52 reactors were built and operated under AEC/DOE authority and current activities such as operation of the ATR and restart of the TREAT facility benefit from that experience. If new reactor facilities are built at the site, that capability should be fully utilized.

INL as a Multi-Program Laboratory

The INL has grown significantly in work associated with homeland security and clean energy research and technology development. DOE-NE and DOE-ID have been excellent stewards of this growth, which has resulted in major advances important to the country. They are to be commended.

This growth has been important in establishing the reputation of the INL as a world-class national laboratory, in attracting significant talent, growing budgets and positioning the INL to be a major player in energy technology development.

Recommendations:

Establish a lead role in examining elements necessary to provide energy security for the nation. *Include evaluation of differing energy technologies, their technical and financial risks, limitations, time for deployment, storage, and environmental impacts.* Focus on developing cooperative programs and support to other laboratories working on energy and environment technologies, introducing nuclear power in context. This recommendation focuses on developing and sharing technical and system-analysis tools.

Develop and demonstrate clean energy systems at scale, taking advantage of the physical INL site and supporting infrastructure.

Enhance national, regional and state security using distinctive lab competencies in nuclear technology and cyber security.

INL as a National Laboratory that advances science

It is important that the INL attract the people, the funding and the attention that will further establish the INL as a world class national laboratory. The unique characteristics of INL which makes it an important national asset are the large area, 890 square miles, nuclear facilities such as ATR, MFC etc., and its location in a sparsely populated area of the country with a highly supportive community. This combination allows for interesting and important programs and projects that simply cannot be done elsewhere. On the other hand, this perceived isolation occasionally presents a barrier to hiring top quality staff. Perceived isolation is not strictly related to physical location. Access to major Universities and other national laboratories is also important.

It is not clear whether the perception of isolation is a real barrier or whether the quality of the problems being addressed by INL offset this relative isolation. Probably both are true on a case-by-case basis. The subcommittee therefore believes that, while INL must constantly be mindful of the issue, the quality of the work, partnerships with other laboratories and universities and the geographic location are assets that can overcome this issue. For those cases where location does matter, flexible working arrangements can be tailored. In fact, in the modern connected environment where one lives and where one works are less strongly coupled than they used to be.

The history of DOE activities in Idaho, inherited by INL, is one that emphasized operation and testing of nuclear facilities, e.g. hands-on engineering and operation. As a result, it is generally believed that INL and its predecessors were not strong in analytic development and innovation. In fact, INL and its

predecessors have developed widely used code systems such as RELAP and MOOSE.

Essential to establishing credentials as a world class laboratory is the quality of partnerships with leading universities both locally and nationally. INL has as part of its contractor team both local (the Idaho Universities Consortium or IUC) and national (the National Universities Consortium or NUC). The NUC includes universities that have world-class stature.

In the decade since the creation of the modern INL significant progress has been made which has established the foundation for a secure future. INL must build upon this foundation of people, facilities, capabilities, and partnerships to raise the scientific and technical impact of the lab addressing big national and global challenges. While continued modernization of facilities and infrastructure is critical the real difference will be in hiring and retaining great people. The committee acknowledges that there has been significant progress in this area. Nonetheless the onrushing "silver tsunami" of retirements offers a once-in-a-generation opportunity to reset the laboratory.

The committee notes that like all multi-program national laboratories there is a main mission, nuclear energy, and subsidiary missions, national and homeland security, and energy and environment in the case of INL. INL needs to ensure that the approach developed is tailored for these very different missions.

The committee recognizes that INL has successfully consolidated expertise and facility capability at the Idaho Site since it was created in 2004. From that beginning, significant progress has been made. Notably:

- Experimental Facilities and Instrumentation has been significantly upgraded.
- Funding levels at the INL have grown as the multi-program nature of the INL has grown.
- Staffing has increased with the hiring of young, well qualified researchers.

- Policies to encourage the new generation of researchers have been established.
- A well-qualified, effective management team is in place.

While the perceived isolation can always be a barrier to recruitment, most often because of the potential recruit's family situation, INL has been able to hire a relatively large number of notable senior research leaders and promising younger staff across all the program areas.

INL has worked to establish strong partnerships with the local universities through CAES as well as joint appointments, e.g. nuclear engineering at ISU. Equally the universities are recognizing the value of having a large research enterprise in Idaho which can be leveraged in a variety of ways. For example, after many years of neglect, the University of Idaho is investing in the Idaho Falls faculty. CAES is a model for the regional partnerships that DOE is trying to promote.

INL has gradually established a reputation as an engineering science laboratory. In recent years the INL brand of strong application oriented science has been nurtured. Products like MOOSE, which is used world-wide for solving difficult physical problems without the need to learn the intricacies of numerical simulation, have helped enormously. Nonetheless, the level of funding from DOE/SC is abnormally low and needs to be addressed.

INL, DOE/NE and the field office have established effective working relationships within the parameters of the current oversight model. Nonetheless the committee believes that there is still too much transactional activity which can act as a brake on progress, consuming resources and inhibiting innovation.

Recommendations:

Evolve the lab culture to one that takes the long view, embraces collaboration and competition on ideas, and that values diversity and inclusion. Attract and support

scientists and engineers who are innovators in their fields, leading to new and important laboratory initiatives.

INL and DOE should make maximum use of flexible working arrangements, where appropriate, to build staff capability. Increase the scientific impact of the lab through high quality publications and innovations and a focus on internal and external collaborations. LDRD funding is low for science development and should be examined for possible increases.

Bring promising technologies and their underlying science to demonstrated products, embracing the range of talent needed to do so. As an applied engineering laboratory with unique test facilities, support an advanced research agenda which will attract young, enthusiastic, talented employees for work that has significant national and global impact.

INL clearly needs to be an engineering laboratory in the modern sense. One that values the synergies between science and engineering. The danger is that INL be pigeon-holed as a place where work is done rather than a true innovator. *It is critically important that INL build up its scientific credentials without sacrificing its unique identity.*

INL should continue to seek ways to work with the IUC and other local universities to strengthen their capabilities. The Idaho universities have become stronger as research entities. INL will benefit in many ways as they continue to improve. INL will be both a more attractive place to work and have access to a deeper pool of potential recruits if the IUC continues to improve. It is also worthy of note that the University of Wyoming has joined the CAES consortium thereby expanding the geographic reach of INL

In spite of much progress, there is limited state-of-the-art equipment and facilities. There is no acknowledgement for the need of a plan for keeping facilities and equipment at the state-of-the-art, as exists with the Office of Science.

Views of the INL from the Renewable Energy Community

The INL and NREL have established important cooperative programs to address the relationship between wind, solar and nuclear. There is both a need and an opportunity for those relationships to be strengthened if the US is to meet its emission goals. Unfortunately, such understanding and cooperation does not exist in other areas such as state governments where policies endangering the continued operation of existing nuclear plants exist. It is incumbent on the Laboratories and DOE to provide the information that can correct unintended consequences and to provide solid technical options for going forward.

There is opposition to nuclear power among many in the environmental community. Often this is due to a lack of understanding of limitations of wind and solar, e.g. why a partnership with nuclear is important. Technical partnerships, however, offer the opportunity to overcome these perceptions, as demonstrated by the strong relationship now developed between the INL and NREL.

Recommendations:

DOE should better coordinate cooperation within the Department between NE and ER. Consistent with this, the INL and NREL should continue to strengthen their working relationships.

Explore and promote nuclear technologies that are compatible with wind and solar. Many of the innovations in nuclear power systems currently being funded by the private investment community are pursing this goal, often leading to smaller systems that can load follow.

Appendix A: Membership of the NEAC Subcommittee

Subcommittee members:
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Christensen, Dana
Cochran, Tom
Corradini, Michael
Hill, David
Khalil, Hussein S.
Klein, Andy
Murray, Paul
Rudin, Mark
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